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INTERACTIVE COURSEWARE (ICW) AND THE COST OF INDIVIDUAL TRAINING

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November 1992

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13. ABSTRACT (Maximum 200 words)

This paper examines the potential cost and personnel savings from wider use of Interactive Courseware (ICW) relative to current instructional delivery methods. Such potential savings are important because 6.7% of the total DoD budget is devoted to instruction and one in every seven military personnel are involved in individual instruction as a student, instructor, or in instructional support. The hypotheses are that wider use of ICW would (1) decrease the cost of training personnel to a given level of skills and knowledge and (2) decrease the number of students in training at any given time. The data support these hypotheses. Using conservative estimates of training costs and ICW savings, we estimate annual savings from wider ICW use to be $130 million to $160 million. The primary source of these savings is less student time under instruction, which should result in a lower training load and allow for less of the overall military personnel ceiling being used on those receiving, giving, or supporting individual training. The student time savings would mean 9-11 thousand fewer students with no loss of training throughput. The paper also discusses the institutional conditions that impede wider ICW use, and recommends ways to overcome these impediments and foster wider use of cost-effective ICW technology.

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INSTITUTE FOR DEFENSE ANALYSES

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PREFACE

This paper was prepared by the Institute for Defense Analyses (IDA) for the Office of the Assistant Secretary of Defense (Force Management and Personnel) [OASD(FM&P)] under contract MDA 903 89 C 0003, Task Order T-L7-798, Manpower Issues, issued 15 March 1990. The objective of the task was to identify promising approaches to maintaining strong military manpower capability during a period of declining budgets and force levels. This is one of a total of seven papers to be published. Each of the seven papers covers a specific area of military manpower management: the proper experience mix, personnel movement, the timing of training, lateral entry, the link between career progression and assumption of management responsibilities, individual training methods, and increased use of simulators for training. The topic of this paper is individual training methods.

This work was reviewed by Waynard C. Devers and William T. Mayfield of IDA and by Harry J. Gilman, an IDA consultant.

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I. INTRODUCTION AND SUMMARY

A. INTRODUCTION

At any given time, one of every seven persons in the active military is receiving, giving, or supporting individual schoolhouse training. In FY 1989, 6.7% of the total Department of Defense (DoD) budget was spent on formal individual training. Therefore, in an era of declining personnel ceilings and declining budgets, it seems appropriate to examine individual training for potential personnel and budget savings.

Over the past twenty years, a wide variety of new technologies for delivery of training have been developed. These technologies are included under the general category of Interactive Courseware (ICW), and include approaches such as computer-assisted instruction, computer-managed instruction, and interactive videodisc instruction. The development of these technologies has been made affordable in large part because of the rapid decline in the price of digital electronics.

The main hypothesis to be examined here is that these ICW technologies offer a cost-effective way to deliver instruction. We examine evidence that ICW will diminish the amount of time students spend in school and decrease the number of instructors needed to deliver instruction. If this is the case, we would accept the likelihood of a decrease in the support personnel requirements for training. We also need to see if these decreases can be achieved at a cost less than the student, instructor, and support pay and allowances saved.

An additional issue to be discussed is whether widespread insertion of ICW training delivery approaches would require a reexamination of the way we determine training requirements.

B. SUMMARY

1. Quantitative Results

The data presented support the hypotheses that money and personnel time would be saved by more extensive use of ICW. The evidence is sparse, but ICW does not appear to be widely used in military training. A rough estimate of the effect of applying these technologies widely in individual, specialized-skill training alone suggests DoD-wide

annual cost savings of $130 million to $160 million. These savings occur if courses that instruct 20-25% of annual student throughput are converted to ICW. The main source of these savings is from a decrease of 20-25% in the average time students are under instruction using ICW compared with conventional methods. These changes would result in 9-11 thousand fewer students in training at any given time with no change in the number of graduates. The development and maintenance costs for these ICW technologies seem to be equal to or less than conventional instructional approaches.

2. Qualitative Issues

Given the forecast price declines in the hardware and software used for ICW, there is every reason to assume its relative cost will fall further. In addition, instructional delivery methods that can be more decentralized and available on student demand may become more important due to possible changes in total force policy, such as those that increase the use of Reserve components.

Many explanations are offered for lack of ICW use. One possibility is that the costs avoided for individual course components may not translate into course sequence time savings. ICW may be under-used because training policymakers are not aware of the full costs of training or because training managers are not given incentives to manage based on those costs. In addition, lock-step instruction may also provide non-training benefits, such as team-building, that are difficult to quantify.

DoD directives and instructions exist that encourage the development and use of innovative technologies. A recently enacted Instruction develops procedures to make it less costly to: maintain and enhance ICW material, find out about its existence, and disseminate it to interested parties.

3. Recommendations

Because ICW training appears to be cost-effective, efforts should be made to develop policy direction that would make consideration of such technologies more common during major revisions of instructional design and delivery methods.

Increased use of ICW will tend to increase the amount of individualization, including self-pacing, in training. This has the potential to change the way students learn and the amount of knowledge they accumulate. If these changes are significant, they may change the amount and kinds of knowledge and skills we want to provide through training.

C. REPORT OUTLINE

The remainder of this report contains four main sections. The next section (Section II) describes the training establishment and reviews current policies on training and current training methods. Section III summarizes the research literature on potential cost and time savings of ICW, and presents a first-order estimate of the cost savings that might result from wider use of ICW in military training. Section IV discusses and analyzes some of the difficulties with and uncertainties about implementing a policy on ICW. It also suggests why we might want to reexamine our approach to training requirements determination. Section V discusses possible policy changes and further analysis that might be undertaken. Appendix A describes a more detailed analysis of Navy data.

II. THE INDIVIDUAL TRAINING ESTABLISHMENT, POLICIES, AND METHODS

This section provides information on the size of the individual training and education establishment and the training load that it supports (most of the measures of size are in dollars rather than numbers of personnel). A brief description of the DoD directives and instructions that guide training policy and a discussion of the instructional delivery methods currently being used are included.

A. THE INDIVIDUAL TRAINING AND EDUCATION ESTABLISHMENT

Data on DoD individual training and education are reported annually in the "Military Manpower Training Report" (MMTR) [1], which is the source of most of the data in this section.

In FY 1989, 6.7% of the DoD budget was spent on individual training.[1] At any one time, approximately 8.6% of the active force was in training, 4.2% was engaged in delivering or directly supporting training delivery, and another 1.4% was allocated to Base Operating Support (BOS) of the training function. In summary, on an average day in 1989, one person of every seven in the active military was either receiving, giving, or supporting individual training. Also, 2% of the DoD civilian workforce was engaged in training and direct training support and 3.7% was engaged in BOS for the training function. Finally, 3.1% of the reserves are in training.[2]

Selected FY 1989 data are shown in Tables 1, 2, and 3. The dollar figures for all individual training accumulated in Subtotal 1 (Table 1) include student pay and allowances as well as all other training costs. Student and instructor loads, sometimes called Average-on-Board (AOB), have been relatively constant over the last ten years (± 5%), and the financial resources are programmed to be of similar constant dollar magnitudes for FY 1990 and FY 1991.

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1 See Reference [2], p. 157, Subtotal, DoD—Military, $290.8 billion.

2 According to Reference [3], end-FY 1989 active force was 2.131 million; Reserves, 1.171 million; and civilians, 1.037 million.

Table 1. Funding of Individual Training by Training Category, FY 1989

Training Category	Millions of Dollars
Specialized-Skill Training	$6,035.2
Flight Training	2,375.4
Recruit Training	1,790.2
Army One Station Unit Training	591.3
Medical Training	841.4
Professional Development Education	725.0
Officer Acquisition Training	530.5
Subtotal 1	12,889.0
BOS and Direct Training Support	4,405.4
TDY Cost for Training	640.0
PCS Cost for Training	370.7
Management Headquarters	155.6
Subtotal 2	5,571.7
Reserve Component Pay and Allowances	940.6
Subtotal 3	940.6
Total	19,401.3

Source: Reference [1], p. IX-4 to IX-6.

Notes: BOS = Base Operating Support; TDY = Temporary Duty; and PCS = Permanent Change of Station.

Table 2. Active and Reserve Training Loads

	Thousands of Personnel
Active	183.8
Reserve and Guard	36.3
Total	220.2

Source: Reference [1], p. 5.

Note: Total does not add due to rounding.

Table 3. DoD Manpower in Support of Individual Training, FY 1989

	End Strength (Thousands of Personnel)		
Category	Military	Civilian	Total
Direct	89.2	21.0	110.2
BOS and HQ	30.1	38.4	68.5
Total	119.4	59.3	178.7

Source: Reference [1], p. VIII-3 and V-III-4.

However, the MMTR understates the magnitude of the total military training enterprise. It only concerns instruction conducted in formal courses by organizations whose primary mission is education or training. It excludes job-site training, factory and unit training for new systems, organized team training for performance of specific military missions, and all field exercises. The magnitude of total resources allocated to training is difficult to determine, but it is likely to exceed the MMTR dollar projections by a factor of two or three.

B. CURRENT POLICIES

This section consists of three subsections. The first subsection discusses the system activities approach to analyzing existing training. The second subsection briefly summarizes the two main training DoD directives and one instruction of interest. The third subsection discusses how these policies affect choices of instructional media. Together, these three subsections provide an analytical approach to conceiving training systems, discuss the procedures that have been codified to implement this analytical approach, and briefly describe the effects of the approach and procedures on the development of instructional media for DoD training.

1. System Activities

System activities consist of analysis, design, production, delivery, and evaluation. *Analysis* in training primarily concerns what to train and what objectives to seek. It takes military missions and the jobs required to perform them as input and produces the learning and production objectives specified for a training system. *Design* establishes the instructional tactics to be used by a training system. Design takes as input the learning and production objectives of a training system and produces specifications for developing the media and training content, or training materials, that are intended to accomplish these objectives in the most cost-effective manner. *Production* takes as input the training system materials specifications established by the design process and produces the training materials to be used in the training system. *Delivery* takes as input training system media allocations from the design process and training materials from the production process and as output provides training to the students. *Evaluation* provides feedback for the training system. It takes as input the performance of training systems and provides as output information on the adequacy of analysis and design decisions and of production and delivery practices.

2. Main Training Directives and Instruction

Most of the current DoD training and education policy is described in two DoD directives and one DoD instruction: DoD Directive 1322.18, "Military Training," 9 January 1987 (Reference [4]); DoD Directive 1430.13, "Training Simulators and Devices," 22 August 1986 (Reference [5]); and DoD Instruction 1322.20, "Development and Management of Interactive Courseware for Military Training," 14 March 1991 (Reference [6]). Other directives and instructions apply, but these three documents provide the foundation of current policy and are generally considered when DoD training and education policy is being discussed.

Summaries of policies and procedures from these directives and instruction are contained in the next three subsections. A discussion of the directive on military training is included because it is central to the understanding of training options. The training simulators and devices directive is discussed because ICW sometimes includes or is included in such simulators or devices, and often simulates actual equipment in training, e.g., maintenance training. The ICW instruction is discussed because it is an important management initiative to lower the cost of maintaining and disseminating ICW technology.

a. DoD Directive 1322.18, "Military Training"

This directive establishes DoD policy for training military personnel and military units. It has only one policy statement which states that "it is DoD policy to provide military training programs for the total force that support force readiness and use resources efficiently." Particularly in individual training, the Directive requires that the the most cost-effective type of training (institutional or on the job) and method of instruction be used. Also, it stipulates that "instructional methods such as individualized instruction that minimize time to meet course objectives shall be considered for use."

Of particular interest to this examination of ICW technology as an instructional delivery approach are the following guidelines:

- "Vigorous research programs shall be conducted to develop innovative training technologies that make military training more effective and efficient."
- "Simulators and training devices shall be used when they effectively and economically supplement training on actual equipment. . ." with improved readiness the primary criterion for their use, and with O&S savings an important secondary consideration.
- "Computer-based instruction shall be considered when analysis determines that its use would be effective and efficient."

- "The use of training technology shall be emphasized in solving the unique training problems of the Reserve components."

b. DoD Directive 1430.13, "Training Simulators and Devices"

This directive establishes policy for simulator and training device development, acquisition, and use, it authorizes the use of simulators and training devices, it supports requirements for coincident and concurrent development of training systems and the military system(s) they support, and it emphasizes the integration of simulators and training devices with overall training systems.

The directive states that policy for simulators and training devices grows out of the general policy of optimizing the operational readiness of the total force. Policy for simulators and training devices is articulated in four categories of guidelines: General, Development Planning, Acquisition, and Training Effectiveness Evaluation.

The directive states that development and acquisition of simulators and training devices within the military services shall be based on each service's training requirements analysis process, and shall include a cost-benefit analysis of alternatives and their potential effects on Active, Reserve component, and inter-service training.

Under acquisition guidelines, the directive states that alternatives to simulators and training devices as well as alternative simulators and training devices shall be evaluated by the service concerned. This evaluation should include life-cycle costs and benefits, and flexibility of the system in response to changes in the system to be maintained and in training location, method, or load. Finally, it mandates that commercial practices, equipment, and software may be used when military-specific requirements do not exist.

c. DoD Instruction 1322.20, "Development and Management of Interactive Courseware for Military Training"

The main goal addressed by this instruction is more cost-effective use of ICW for military training. The instruction concentrates on meeting this goal by designing and mandating the implementation of procedures that enhance the efficient distribution of ICW materials and information. These procedures include requiring certain standards for developing: ICW materials, an automated information system for archiving ICW materials, and archiving procedures (such as keeping copies of the course-authoring software) that will reduce the expense of modifying and transferring this technology throughout DoD. In summary, this instruction implements procedures that lower the effort (cost) of both finding out about already-developed ICW and transferring ICW to other organizations.

3. Do Present Policies Further Systems Activities with Respect to ICW?

The main hypothesis to be examined in this paper is that ICW technology offers a cost-effective way to deliver instruction and that it should be more widely used. A key question is: How do training activities, directives, and instructions address ICW technology in training delivery? Since the choice of instructional medium is made in the design activity, we will evaluate how design is addressed in general, and how technology such as ICW is addressed in particular.

Design is addressed by all three documents previously mentioned. The directive on simulators and training devices states that alternatives to simulators and training devices as well as alternative simulators and training devices shall be evaluated. It goes on to list four specific elements that are to be included in each evaluation. The directive on military training states that systematic procedures shall be used to design individual training. It goes on to list seven activities that shall be included in these procedures, including determining the proper allocation of training to institutional training and on-the-job training and choosing the most cost-effective methods of instruction. The instruction on ICW attempts to ensure that usability be seriously considered at the design stage by stating that ICW shall be designed with an open architecture and that it be developed to promote its cost-effective use, its portability among DoD components, and its efficient distribution to all potential users.

Two of the documents support innovation and progress in the design of training programs. The military training directive states that vigorous research programs shall be conducted to develop innovative training technologies that make military training more effective and efficient. It also states that the use of training technology shall be emphasized in solving the unique training problems of the Reserve components. Finally, it states that computer-based instruction shall be considered when analysis determines that its use would be effective and efficient. The ICW instruction is strongly motivated by the need to promote new, more effective, and more efficient approaches to training. It should accelerate the use of ICW by promoting portability, freedom from royalty, license, and other run-time fees, and the preparation and storage of master copies for easy reproduction and distribution of ICW materials.

In summary, these documents address instructional design, and specifically encourage ICW where appropriate. Consistent with this encouragement, DoD has been a leader in the development of instructional technology as reported in reviews by Fletcher and Rockway [7] and the Office of Technology Assessment [8]. Areas where DoD has pioneered and provided technology leadership include: computer-assisted instruction,

computer-managed instruction, intelligent instructional systems, interactive videodisc instruction, computer-assisted testing, training device development, applications of high-fidelity simulators such as flight trainers, applications of part-task, lower-fidelity simulations such as maintenance trainers, courseware portability, simulation networking, and systems approaches to instructional systems development. Other agencies of the government and the civilian sectors have adopted these DoD innovations for their own use.

Given that ICW technology is encouraged by these DoD policies, let's look at how widely these tools are used by DoD.

C. CURRENT TRAINING METHODS

We were able to find, collect, and analyze Navy data provided from Chief, Naval Education and Training (CNET) databases on the current use of self-paced ICW. On balance, we believe the evidence obtained shows significantly less use of ICW, and particularly self-paced ICW, than is desirable given the cost savings reported in the next section. Conclusive evidence on the current use of self-paced ICW for the other military departments could not be obtained within the constraints of this project. Our discussions with organizations within the Army and Air Force that collect training data indicated that their data were not available in a machine-readable form that could be easily analyzed.[3]

The Navy data is presented below in Tables 4 through 7. We combined 1989 data on Navy courses with 1985 data from a prior study (Byrnes and Schoeck [9]) to examine some trends over time. Both 1989 and 1985 data were extracted from the Navy Integrated Training Resource Analysis System (NITRAS). Additional, more detailed analyses of the 1989 data are provided in Appendix A.

Table 4 shows, for each type of course, the percentage of courses that have each of the different methods of instruction shown. Table 5 shows, for each type of course, the proportion of student load or Average-on-Board (AOB) for each method of instruction.

The methods of instruction highlight two aspects of this instruction: whether or not it was in some way computer-mediated and whether the instruction was individualized through self-pacing and self-sequencing. Computer mediation may involve only management of the course (tracking grades, allowing exams to be taken on demand), or the computer may be a major vehicle for delivering instruction.

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[3] DoD Instruction 1322.20 (Reference [6]) mandates the development of the Defense Instructional Technology Information System, which should make this information more easily available in a consistent format.

Table 4. Course Counts and Percentages by Method of Instruction, FY 1989

Type Course	Percentage by Method of Instruction[a] Self-Paced, Instructor-Managed	Self-paced, Computer-Managed	Group-Paced, Computer-Assisted	Group-Paced (Lock-Step), Instructor Managed	Missing/Other	Total Courses
Initial	2.2	4.1	25.5	68.2	0.0	314
Advanced	0.7	0.2	1.6	97.3	0.3	2,768
Team/Fleet	1.2	0.0	0.4	98.1	0.3	1,426
Total	0.9	0.4	2.9	95.5	0.3	4,508

[a]Percentages add to 100 across the rows.

Table 5. Student Loads (AOB) and Percentages by Method of Instruction, FY 1989

Type Course	Percentage by Method of Instruction[a] Self-Paced, Instructor-Managed	Self-paced, Computer-Managed	Group-Paced, Computer-Assisted	Group-Paced (Lock-Step), Instructor-Managed	Missing/Other	Total Load
Initial	1.1	3.4	44.7	50.7	0.0	23,048
Advanced	0.9	0.2	4.3	94.2	0.4	16,002
Team/Fleet	0.7	0.0	0.4	98.4	0.5	4,070
Total	1.0	1.9	25.5	71.4	0.2	43,119

[a]Percentages add to 100 across the rows.

The interesting data are in initial skill training courses, since that is where most of the large, high-throughput courses are located. In these data, 32% of the courses and 49% of the AOB are in self-paced or computer-mediated instruction, or both. That is, these are not lock-step, instructor-managed courses. If these data can be interpreted in this straightforward manner, and if they are representative of the Air Force and Army, then it would seem there is significant penetration of ICW technology, and that the level of training expenditures is lower than it would otherwise be, though not as low as possible.

However, such straightforward interpretation is difficult for the group-paced, computer-assisted instruction (CAI) category. The problem of interpreting this category is that the easiest cost savings to identify in ICW are reductions in student time, which occur through instructional individualization in general and self-pacing in particular. These

savings are less likely to be realized in a group-paced environment.[4] That is, if self-pacing is the characteristic of these training courses that generates cost avoidance, then only 6% of the initial training courses and 5% of the initial training load benefited from cost avoidance generated by ICW.

In Tables 6 and 7, an attempt is made to compare 1985 and 1989 data to see if there are discernable trends. Unfortunately, the 1985 course counts are not presented in as disaggregated a form as the 1989 data, so in Tables 6 and 7 the 1989 data are aggregated accordingly. Also, the 1985 data use maximum course input as a size estimator, so the load comparison is not clear.

Table 6. Comparison of 1989 and 1985 Course Counts

		Percentage by Method of Instruction			
Year	Type Course	Self-Paced	Lock-Step	Missing/Other	Total Courses
1989	Initial	6.4	93.6	0.0	314
	Advanced	0.8	98.9	0.3	2,768
	Team/Fleet	1.2	98.5	0.3	1,426
	Total	1.3	198.4	0.3	4,508
1985	Initial	32.5	67.5	NA	412
	Advanced	1.2	98.8	NA	4,200
	Team/Fleet	2.2	97.8	NA	1,933
	Total	3.4	96.0	0.6	6,585

Notes: NA means not available. Lock-step data for 1989 are an aggregation of the group-paced, computer-assisted and the group-paced, instructor-managed columns in Table 4.

A comparison of the 1989 and 1985 data in Table 6 is interesting. One key item is that, in 1985, 33% of the advanced school courses were self-paced, while in 1989 only 6% of those courses were self-paced. Since self-pacing for individual courses results in less time under instruction, it is not clear why this change has occurred. It was most probably the result of a CNET policy decision in the mid-1980s against use of self-pacing, resulting in efforts to convert self-paced courses back to group-pacing.[5]

4 A similar observation is made in Orlansky [10], p. 400-402.

5 See Section IV.B.2 of this paper for possible reasons for this policy.

Table 7. Comparison of 1989 Student Load with 1985 Average Maximum Yearly Input Capacity

Year	Type Course	Percentage by Method of Instruction: Self-Paced	Lock-Step	Missing/Other	Total Courses
1989 (Student Load)					
	Initial	4.6	95.4	0.0	23,047
	Advanced	1.1	98.5	0.4	16,002
	Team/Fleet	0.7	98.8	0.5	4,069
	Total	2.9	96.9	0.2	43,120
1985 (Average Maximum Yearly Input Capacity)					
	Initial	69.1	30.9	NA	1,111
	Advanced	2.9	97.1	NA	86
	Team/Fleet	3.4	96.6	NA	388
	Total	22.4	77.6	NA	239

Notes: NA means not available. Lock-step data for 1989 are an aggregation of the group-paced, computer assisted and the group-paced, instructor-managed columns in Table 5.

In summary, the available data indicate that the advantages of self-pacing in lowering student instructional time have not been embraced by the Navy. Unfortunately, definitive quantitative findings and conclusions with respect to DoD-wide ICW usage are difficult to generate due to lack of data for the Army and Air Force. However, qualitative assessments by Army and Air Force training experts do not suggest extensive use of ICW and self-pacing in these services. As can be seen from the Navy data, the use of self-pacing in initial training is not as great as might be expected and it seems to have decreased during 1985-1989.

III. COST SAVINGS FROM ICW

This section provides first-order estimates of the cost savings that may be available through the insertion of ICW technology in place of existing lock-step technology. Based on a set of what we believe are conservative assumptions, this analysis suggests that more extensive application of ICW technology to individual training wiu result in both financial and personnel savings. The analysis estimates annual savings of $130 million to $160 million if ICW were applied to specialized-skill training only. These savings result primarily from less student time spend under instruction, hence a lower training load to achieve a given output of trained personnel. Training load would decrease by 9-10 thousand personnel.

The analysis that supports these estimates includes a review of prior research literature on the costs and benefits of different training technologies, specifically research on the percentage cost and time savings from ICW. Savings estimates are developed in two stages. The first stage applies these savings percentages to easily identifiable, direct costs of specialized-skill training for active forces. The second stage involves estimating savings to cost of training Reserve components, as well as less direct training costs such as Base Operating Support. A more detailed analysis of Navy Initial Skill data is presented in Appendix A.

Each stage presents a range of estimates based on different assumptions about the range of time savings and the proportion of courses to which these savings apply. In addition, several other trends are discussed that have implications for the size of these savings estimates.

A. COST AND TIME SAVINGS ESTIMATES FROM THE RESEARCH LITERATURE

The potential of some form of ICW as an instructional medium has long been recognized. However, there have also been questions about whether this potential could be realized in a cost-effective manner. This uncertainty has led to a wide variety of studies as new variants of this technology (e.g., computer-based, computer-aided, or computer-managed instruction, interactive videodisc instruction, and multimedia instruction) have been introduced. This section briefly describes several citations in the literature, and extracts cost and time savings estimates for use in our rough cost estimate.

1. Literature Reviews

The three main sources used here are Orlansky [10], Fletcher [11], and DeBloois [12]. All these documents are themselves summaries of previous cost, effectiveness, and cost-effectiveness studies of ICW. For example, Fletcher summaries 28 studies (13 military training, 4 industrial training, and 11 higher education studies) and DeBloois summarizes 30 studies (6 military). Orlansky summarizes several studies that are themselves summaries of other studies. There is some overlap in the studies summarized by DeBloois and Fletcher; 9 are common to both reports.

2. Cost Drivers, Costs, and Savings

For the cost analysis undertaken here, we need estimates of both the benefits (savings) of ICW and the investment necessary to obtain those savings.

A major cost driver for training is student pay and allowances; hence, an important potential source of savings is the reduced time students require to pass through ICW courses. A major reason for faster course completion is that ICW courses are individualized, and the pace, content, and sequence of instruction is tailored to the needs and capabilities of each student. Because of this individualization, as opposed to group-pacing or lock-stepping students through courses, students complete courses sooner and student pay and allowances attributable to training are less than they would otherwise be. Also, the average number of students in training at any given time can be reduced.

With respect to cost avoidance through decreased student instructional time, the cited works show substantial consistency. Orlansky ([10], p. 400) reports a median 30% savings in student time, Fletcher ([11], p. III-23) reports a 31% savings in student time, and information from DeBloois [12] can be used to estimate a similar savings in student time (26% mean, 30% median; removing the studies duplicated in Fletcher does not change this result appreciably). The figure of 30% is used as the starting point for our analysis.

The expense that must be incurred to produce these savings is not as well summarized in the cited reports. However, by examining several of the primary sources, a case can be made that the life-cycle costs of ICW are no greater than the costs of the technologies they replace.[6] For example, Fletcher enumerates seven studies that report comparisons of initial investment, operating and support, and/or full life-cycle costs

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6 Some care must be taken with this result, because some of the original instructional delivery methods involved actual equipment whose costs are usually high, and some involved lecture-like delivery approaches where course development costs are lower.

between then-existing training and ICW training and that do not include cost savings due to less student time. In each case, the comparison favored ICW. He also reports two studies where cost comparisons include cost savings due to less student time. These also favor ICW, and continue to do so even when student cost savings are removed.

3. Summary

In summary, these studies suggest that greater use of ICW should result in lower costs as well as fewer personnel in training at any given time. The net life-cycle costs of the ICW technologies themselves do not appear to be greater than existing technologies.[7] Therefore, when ICW technologies are applicable and used in ways that allow the individualization inherent in these technologies to be expressed in different course completion times, the 30% student time savings (hence savings in student, instructor, and support pay and allowances) is not offset by higher ICW costs.

The next question is: Given the student time savings and other benefits found in the literature, if ICW, and particularly self-paced ICW, achieved wider use, what sort of potential savings might be available?

B. POTENTIAL SAVINGS

In order to estimate overall cost savings from the introduction of ICW technology into individual training, we need additional information beyond that discussed so far. In particular, we need to know what percentage of the individual training budget is subject to savings from the introduction of ICW.

We developed an estimate of the potential savings from ICW introduction in two stages. First, we considered the direct costs of specialized skill training for active forces. Within specialized skill training, we estimate the percentage of training load in courses that might be converted to ICW and the percentage of student cost savings that might result from such conversions. Wide ranges of course conversions and student cost savings are

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7 It could be argued that life-cycle cost comparisons are less appropriate in a situation where one training delivery system already exists, say, small group instruction on actual equipment, and the alternative is ICW technology. Because parts of the existing approach already exist (are fixed), the correct comparison would then be the variable cost of the existing approach versus the total cost of the alternative approach. This might be correct in special cases, but as has been argued elsewhere (Sullivan [13]), it is quite reasonable to believe that important aspects of operating procedures, systems, and platforms are changing at a rate rapid enough that there are very few fixed procedures or equipment for more than a few years. As long as such changes are occurring rapidly, both alternatives should be measured by life-cycle costs.

used because the savings obtained from converting a single course may be lost when sending students through a sequence of courses, not all of which are self-paced. A detailed explanation of how those savings may be lost is given later.

Second, we included cost allocations that account for Reserve Components, Base Operating Support (BOS), Temporary Duty (TDY), Permanent Change of Station (PCS), and Army One Station Unit Training (OSUT). These estimates are described separately because of their lower precision.

Three assumptions are maintained through this analysis. First, we assume that the extra cost of ICW is balanced by reductions in instructor pay and allowances and acquisition and maintenance expense for actual equipment. Thus, these values are not included in the savings estimates.

Second, students are trained to given criteria regardless of the instructional delivery method used. That is, whether ICW or lock-step instruction is used, students learn the same skills and knowledge and are therefore equally productive in their assignments. This assumption will be further discussed in Section IV.

Third, the standard sequence of enlistment, basic training, initial skill training, and initial assignment will be maintained. It may be that additional training savings could be obtained if more entering personnel were routed from basic training through an initial assignment, and then back for initial skill training (see Wilson and Horowitz [14]). In the latter case, it might be that ICW could be used to augment the training received in the initial assignment and lower the training costs. However, this more difficult analysis—difficult because readiness is also being traded for potentially lower costs—is not pursued here.

1. The Direct Costs of Specialized-Skill Training

The direct cost of individual training estimated for fiscal year 1990 is $12,889 million, as shown in Subtotal 1 in Table 1.[8] Of that amount, $6,035 million is for specialized-skill training, of which $2,108 million (35%) is student pay and allowances.[9] The breakout within specialized skill training is shown in Table 8. The first savings estimate is generated from student pay and allowances.

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8 Some portion of the TDY costs are direct, but we did not to try to determine how to allocate them.

9 Estimates of the proportion of direct training costs that are student pay and allowances were provided to us by the Training Performance and Data Center (TPDC).

Table 8. Direct Costs of Specialized-Skill Training

Category	Cost in Millions of 1989 Dollars: Direct Costs	Cost in Millions of 1989 Dollars: Student Pay and Allowances	Student Pay and Allowances as a Percentage of Total
Army	2,517.2	859.3	34
Navy	2,046.5	811.3	40
Marine Corps	511.5	220.0	43
Air Force	960.0	217.8	23
Total	6,035.2	2,108.4	35

2. Savings Estimates

An overly optimistic cost avoidance estimate would be to take the student time savings factor of 30% and apply it to the entire student pay and allowances figure to generate a savings estimate of $633 million. However, there are several reasons to believe this would be inappropriate. For example, for small throughput courses, the fixed cost of ICW media preparation would tend to overwhelm the time savings. Also, there is probably some irreducible minimum amount of waiting time during training that prevents the 30% savings in instruction time in an individual course from translating perfectly to a 30% cost savings for instructional sequence. Finally, we are not sure what percentage of the student load is in courses that are susceptible to cost savings through conversions to ICW.

The different savings estimates we developed depend on different assumptions about the proportion of student load that can be converted to ICW,[10] and the percentage of student costs that can be saved through use of ICW. These results are presented in Table 9. For example, if the student time/cost savings percentage is 25%, and the proportion of student load that can be converted is 25%, then the annual cost avoidance would be $132 million.

[10] It is important to note that there are several courses or course sequences that contain disproportionate amounts of the specialized-skill training load. For example, 2% of the Army training load is in Administrative Specialist, 2% of the Air Force load is in Apprentice Communications Computer Systems Operator, and 4% of the Navy training load is in Avionics Technician A school (though the latter is a multi-threaded course due to training for different airframes). Conversion of a small number of courses or sequences such as these would bring large changes in student time. See Reference [1], p. V-7 for the data from which these figures were generated. See Appendix A for a more detailed breakdown of Navy courses and training loads.

Table 9. Savings in Student Pay and Allowance for Specialized-Skill Training

Percentage of Student Time/Cost Saved	Savings (in Millions of Dollars) by Percentage of Student Load Affected							
	5%	10%	15%	20%	25%	30%	35%	40%
5%	5	11	16	21	26	32	37	42
10%	11	21	32	42	53	63	74	84
15%	16	32	47	63	79	95	111	127
20%	21	42	63	84	105	127	148	169
25%	26	53	79	105	132	158	184	211
30%	32	63	95	127	158	190	221	253
35%	37	74	111	148	184	221	258	295
40%	42	84	127	169	211	253	295	337

In this example, the overall student time savings would be 6.25% ($0.25 \times 0.25 = 0.0625$). From Table 2, the average student load is 183.8 thousand, hence the personnel saving would be 11.5 thousand (183.8 thousand $\times$ 0.0625).[11]

3. Other Factors that Affect Savings

Other factors may influence the size of these savings. These factors affect the fraction of cost saved, the proportion of load in converted courses, and the amount of savings.

As already noted, there is some uncertainty that any given percentage of student time savings translates into an equivalent percentage of cost savings in student pay and allowances. Also, while individual course components can be shortened on average, full course sequences that are mixtures of lock-step and self-paced components mean that individual component time savings may not translate into course sequence time savings. Both these factors tend to move the most likely estimate toward the upper left-hand corner of the Table 9 matrix, and hence towards smaller savings.

However, several other factors suggest that the savings in any given cell in the matrix are underestimates of total savings. These factors are summarized in Table 10. For example, slightly over 52% of the Reserve Component training load is in specialized-skill training ([1], p. 6 and V-2). Therefore, approximately $485 million of the Reserve component pay and allowances from Table 1 could be added to the student pay and allowances from which these savings are factored. This would increase savings in each cell by approximately 23%.

[11] See Appendix A for Navy data that show 20-25% of total student load is in a small number of specialized-skill training courses.

Other factors could increase the amount of possible savings. For example, some component of BOS would vary with training load; approximately 50% of Army OSUT training is spec· lized-skill training; and some part of TDY and PCS expense is dependent on student time. While cost estimates for these categories are less precise, rough estimates and their justification are presented in Table 10.[12]

Table 10. Additional Savings from Other, Indirect Sources

Savings Source	Percentage Increase in Savings
BOS[a]	52%
Reserve Components Pay and Allowances[b]	23%
TDY and PCS[c]	15%
Army OSUT[d]	4%

[a] Fifty percent of $4,405 million in FY 1989 dollars BOS in Table 1 is allocated to specialized-skill training based on proportion of total direct costs. Fifty percent of that is assumed to vary with student time (based on a conservative interpretation of ongoing IDA research). The result is approximately $1,101 million, or 52% of student pay and allowances.

[b] As explained in the text, $485 million.

[c] Data provided by TPDC report $1,240.7 million of TDY is already included in the $6,035 million in specialized-skill training. If 25% of this total amount varies with student time, this yields another $310 million in savings.

[d] Student pay and allowances at OSUT are $172.3 million, approximately one-half of OSUT training is specialized skill.

The level of precision on these estimates is very low. However, if these savings were realized, the value in every cell in the Table 9 matrix would increase by a total of 94%, as shown in Table 11. Using this table, if the actual cost savings percentage were 20% and the proportion of training load in courses that can be converted to ICW were 20%, then the annual cost avoidance would be $164 million.[13]

Personnel savings estimates are also rough. They would include 4% ($0.2 \times 0.2 = 0.04$) of active and researve load (8.8 thousand), and an unknown number of BOS personnel.

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[12] Once again, instructor pay and allowances are assumed to be part of the comparison of life-cycle cost of different instructional technology options.

[13] The range of the estimates ($132-$164 million) could be much larger by reporting the student pay and allowance costs in Table 9 at the 20% cost and load levels ($84 million); and the total costs from Table 11 at the 25% cost and load levels ($256 million). However, we believe the extremes in this range are less likely.

Table 11. Estimates of Total Savings in Student Pay and Allowance for Specialized-Skill Training

Percentage of Student Time/Cost Saved	Savings (in Millions of Dollars) by Percentage of Student Load Affected							
	5%	10%	15%	20%	25%	30%	35%	40%
5%	10	20	31	41	51	61	72	82
10%	20	41	61	82	102	123	143	164
15%	31	61	92	123	153	184	215	245
20%	41	82	123	164	205	245	286	327
25%	51	102	153	205	256	307	358	409
30%	61	123	184	245	307	368	429	491
35%	72	143	215	286	358	429	501	573
40%	82	164	245	327	409	491	573	654

4. Other Trends

Several other trends indicate that even the estimates in Table 11 may understate the potential savings from greater conversion to ICW technology. First, centralized training may become more difficult because future Total Force plans may include a greater reliance on Reserve components. Second, there are more materiel systems to be maintained and these systems are technically more complex, which may result in even larger training requirements; hence, more savings may be possible through the use of ICW. Third, the cost of digital electronic technology, an underlying ICW cost driver, has fallen dramatically in the past, and will continue to do so over the foreseeable future.[14] These factors are discussed in the following subsections.

a. Future Difficulties in Centralizing Training

A potential difficulty in centralizing training would occur if there is an increased reliance on Reserves in the Total Force. For example, Desert Storm and Desert Shield are offering new insights about the relative readiness and effectiveness of different types of Reserve units. If a greater reliance on Reserve components becomes policy, it could strongly effect the choice of cost-effective training design.

Reserve components have a limited amount of time to train, units are widely dispersed throughout the country, some units are not fully equipped, and only a small full-time force of qualified supervisors and trainers exists in many Reserve units. Relatively

[14] One trend that might lower the total savings is overall reduction in the military services. That is, in a steady state, a 20% smaller military would require 20% less training. However, whatever proportional savings are generated are still available, e.g., 25% time savings for whatever the student load. Also, decreasing the numbers of personnel that are receiving, giving, or supporting training while maintaining training output means that a given personnel ceiling allows a larger deployed force.

more Reserves mean that it may become more cost-effective to deliver standardized training to the students than to deliver students to centralized training facilities. The ability of individuals to receive this training will be enhanced if the training has the flexibility to be delivered at any time and in any location the student is available.

It has been argued that ICW offers great potential as a flexible, decentralized instructional delivery method. Walker [15] has done an analysis of the interactive videodisc approach to decentralized training and estimates that, over a three-year life cycle, interactive videodisc would cost 35% of centralized training methods.

If this analysis is borne out, it has further implications for the cost-effective use of ICW in centralized individual training. If Total Force policy initiatives that imply a greater reliance on Reserve components are implemented, and if the full cost of developing ICW cost is less than the marginal cost of centralized training for these personnel, then these technologies will exist and be available for active force centralized training at a very low cost. This makes ICW training even more likely to be a cost-effective alternative to centralized training.

b. The Number and Complexity of Systems

The number of military systems has been increasing. At the end of World War I, 500 materiel systems were fielded by the the U.S. military. At the end of World War II, this number had increased to about 2,000, and currently about 4,000 systems are either fielded or in planning. In the Army there are about 0.78 large systems per person—one wheeled vehicle for every four people, one tracked vehicle for every 20 people, one radio for every 6 people, one generator for every 10 people, and so on. If no technological changes were made in the complexity of military systems, their quantity and variety would by themselves substantially increase the demands on military training to provide the people needed to operate and maintain them.

The technological complexity of military systems is increasing. In 1939, the volume of technical documentation required for the J-F Goose "Catalina Flying Boat" was 525 pages of information. In 1962, the volume required by the A-6A Intruder was about 150,000 pages of information. The volume required for the F-14 Tomcat in 1975 was about 380,000 pages of information and estimates for the B-1 bomber in 1979 were in the

neighborhood of 1,000,000 pages of information. (All technical documentation data are from Kline and Gunning, [16].) This trend will doubtless continue.[15]

The demand for people prepared to hold jobs classified as technical or highly technical has increased, whether due to the number or complexity of weapons systems. The Army projected the number of people required in jobs categorized as "Very Technical" and "Technical" would increase by about 6% from 1984-1990, and the Navy projected an increase of about 14% in "Highly Technical" and "Technical" categories over the same period (Binkin, [17]).

If job complexity and the number of people to train in those jobs continue to increase, the demands on training resources increase concomitantly. The student time savings that result from use of ICW and, especially in this case, the considerable savings that result from the substitution of ICW simulations of devices and situations for actual equipment and situations will become increasingly important (e.g., in maintenance training).

c. Digital Electronic Technology Costs

The hardware and software costs for a given quality and quantity of ICW will continue to fall over time for three reasons. First, the cost of computer hardware has been falling rapidly over time. Second, microcomputers are being substituted for mainframes as the host for ICW, and these microcomputers are cheaper for a given amount of computer power than are mainframes. And third, cheaper hardware means that hardware can be substituted for personnel and software in the ICW provision process, providing a lower cost delivery system, or allowing greater capability at the same price.

Mainframe Hardware Costs. A wide range of studies has demonstrated that constant-dollar prices for computer hardware—central processing unit (CPU) and random access memory (RAM)—for a given amount of computing power on mainframe computers have fallen 20-24% per year since 1953. (See Triplett [18] for a survey and synthesis of these studies.) Prices for disk drives have fallen almost as rapidly (see Cole et al. [19]). This results in an order-of-magnitude decrease in the price of computer systems of similar power and storage every 9-10 years.

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[15] Whether the complexity of military systems necessarily translates into increased job complexity is a topic of continuing debate. However, several suggestions for diminishing the effects of system and documentation complexity involve greater use of computer technologies for documentation storage; therefore, future maintenance procedures will involve using the same equipment normally associated with ICW.

Microcomputer Hardware Costs. The price of microprocessor computer power is falling at the rate of 25-30% per year (Berndt and Griliches [20]). This is an order-of-magnitude decrease in price-per-unit power every 7-8 years. There are reasons to believe this decline will continue over the coming decade [21]. Also, microcomputers are significantly less expensive per unit of power than are larger computers. Ein-Dor [22] estimates that a microcomputer can deliver a given amount of power at a price approximately two orders of magnitude less than that of mainframes.

Therefore, as a given-price microcomputer becomes more powerful, ICW applications can migrate to it for large potential cost savings.[16] These savings have already been empirically demonstrated in civilian education applications (Fletcher, Hawley, and Piele [23]).

Hardware Substitution. Reductions in hardware prices may appear to be self-limiting if we assume that current combinations of hardware, software, and courseware are immutable. For example, Kemner-Richardson et al. [24], p. 37, cite a study that "reported in their cost analysis of a time sharing system that computer equipment represented only about 28 percent of the total annualized costs, so that even if equipment costs declined by one-third, total costs would be decreased by less than 10 percent."[17]

The point missed in the above quote is that, as hardware prices fall, cheaper hardware will allow hardware and software to substitute for personnel, to produce the same or superior output. A common instance of this sort of behavior is buying a faster computer in order to complete a project—an example of the familiar response of "throwing hardware at a problem." Another example would be using sophisticated course-authoring software

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16 The computer power advantage of microcomputers over mainframes is not as great as the two-order-of-magnitude figure would indicate, because central computers can be shared by many users, and each of these users would need their mainframe terminal replaced by a microcomputer, which is much less shareable. However, the combination of cost issues, such as faster price fall and lower cost per unit power, and capability issues, such as greater interactivity with the user, are such that ICW provision is becoming more and more microcomputer-oriented.

17 See Levin and Woo [25], or Levin, Glass, and Meister [26].

on a microcomputer to generate ICW.[18] Quantitative analysis of these substitution possibilities is an interesting research topic, but far outside the scope of this paper.[19]

It should be emphasized that, as with the mainframe and microcomputer costs already mentioned, hardware substitution will result in a lower price to produce a given level of training. We may instead choose to produce more expensive training systems to deliver more effective training—training that was not previously provided because it was not perceived as cost-effective.

Summary. Declining hardware costs and substitution of hardware for personnel and software are making ICW more affordable. These changes mean ICW applications are becoming more cost-effective. Existing ICW applications are even cheaper, analyses that concluded ICW was not quite cost-effective as other formal teaching methods will be reversed, and increasingly demanding requirements may be more affordable met with ICW. This has profound effects on the design of training systems discussed in II.B.1.

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18 A familiar, non-training example of a more complex version of this substitution is the development of graphical user interfaces (GUIs), first on the Xerox Alto and Star systems (circa 1980), then on the Apple Lisa and Macintosh (introduced in 1983-84), versions of Microsoft Windows (various versions introduced 1985-1992) for IBM PC compatibles, and in X-Windows and Motif for Unix platforms. More powerful CPUs, more memory, and better displays are combined with extremely complex software (which would be much more difficult to develop and improve without inexpensive hardware and the better tools developed because of the existence of that hardware) to make using computers easier. The same sort of changes are occurring in ICW.

19 A quantitative measure of the ease with which one input (e.g., computing power) may be substituted for other inputs in the production process is called the elasticity of substitution. It measures how changes in the relative prices of inputs work through the production process to change the proportions of inputs used to produce a given output. This relationship is constructed to lie between 0 and ∞, with larger values indicating easier substitution. One result available from the literature (Ferguson [27], p. 104) indicates that, as long as the elasticity of substitution between computer hardware and software in the production of ICW is greater than one and the price of computing power continues to fall, output growth would not be constrained by an inability to substitute hardware for software. However, our willingness to purchase this output may be constrained by its total cost, and it is not clear that the elasticity of substitution is in fact greater than one.

IV. POLICY ISSUES, POLICY OPTIONS, AND RESEARCH AREAS

This section examines two issues. The first issue is the possibility that cost and time savings for individual course components may not translate into savings for course sequences or as part of the total process of training and assignment. The second issue is the important longer term effect of incorporating significant amounts of ICW into training—the fact that this use of ICW may affect the requirements for the amount and kinds of knowledge and skills that the military wishes to deliver to students.

A. IMPEDIMENTS TO ICW INCORPORATION

Because ICW allows self-pacing and other forms of individualization, the incorporation of ICW technology into course components results in significant savings in student time as better students assimilate the material more quickly. Also, the studies previously cited indicate that both initial investment and operating and support (O&S) costs of ICW are no higher than the technology that they replace. However, while self-paced ICW technology is being used in individual training, it does not seem to be used as widely as these potential savings estimates would indicate.

Our discussions with individuals who manage and analyze training yielded several possible explanations for this phenomenon. The two most common explanations dealt with (1) problems in combining lock-step and self-paced courses, and (2) additional, qualitative benefits of group-pacing and instructor-mediated training. We do not believe these issues overwhelm the cost savings estimated in Section III, but they should be raised.

1. Combining Lock-Step and Self-Paced Courses

Although course components can be shortened through ICW while still training to criteria, full courses or course sequences that use mixtures of lock-step and self-paced components mean that individual course time savings may not translate into overall time savings.

A hypothetical example would be the following. A specialized skill training sequence currently has three, two-week, lock-step course components labelled A, B, and C. The courses follow one another, so they start two weeks apart. If course B is

converted to ICW, the number of days it will take individuals to obtain the knowledge disseminated in the course will change from 10 to a range of 5-12. Those who finish early will be forced to wait for course C to start, while those who take longer than 10 days will miss their lock-step class and have to wait for the next C course to begin.

A similar problem exists in the incorporation of training in the larger process of personnel movement to and from training. For example, if Navy personnel are to be assigned to a ship, but cannot report until the ship is in port, an early completion of their training will simply mean they must await assignment for a longer period.

If either or both of these situations characterize much individual training, then the cost-effectiveness of ICW will be decreased. However, the pervasiveness of these situations needs to be supported or refuted with evidence, not accepted or rejected without examination.

One reason to think that this problem may be overstated is that those who directly manage training do not necessarily bear the full cost of additional student time under instruction. This is because training managers do not pay students from their budgets, and higher level management does not have accepted, incremental cost-to-train data that include student pay and allowances.

Because many training managers' budgets do not include student pay and allowances, students are less costly to them; hence, the managers will not necessarily optimize the amount of time students spend in training. In fact, our observation has been that a "small" amount of free time by students yields free labor for necessary tasks in training facilities.[20] Also, because training budgets do not show student pay and allowances, it is harder for higher level management to observe the cost-effectiveness of student personnel use.

One policy initiative that is attempting to better address this issue is the DoD(Comptroller) initiative on unit cost of military training. "Unit cost" here means cost of a unit of output, often taken to mean a graduate of a particular set of courses. This initiative is motivated by the need to obtain meaningful cost-to-train estimates for budgetary and policy purposes. Such cost estimates are important to many training management decisions, one of them being the incorporation of ICW technology into training.

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[20] However, when the free or waiting time for students becomes "large" or "excessive," as it did in several Navy training facilities in the early 1970s and early 1980s, higher level management's attention results in significant incentives to correct this imbalance.

2. Qualitative Benefits of Group-Pacing and Instructor-Mediated Training

There appear to be three main qualitative benefits of lock-step and instructor-mediated training. One is the additional military training and discipline realized through the processes of lock-step training with military instructors. Unit cohesion may be greater and discipline more evident in these situations. Second, group-paced training may result in team-building among students if fast learners are used as tutors for slow learners. Finally, instructor mediation often results in additional information being disseminated. For example, lessons that include phrases such as "Let me tell you how it is really done . . ." or "We deviate from these procedures when . . ." may provide connections between knowledge and skill and their application that are difficult to achieve in a self-paced, computer-mediated environment.

These benefits are not inherently qualitative, but few attempts have been made to measure and quantify them. They are widely believed and reported by members of the military training communities, and for this reason must be taken seriously as credible benefits from lock-step, instructor-mediated instruction.

These benefits are not incompatible with the use of ICW programs (McCombs and Dobrovolny [28]). However, the general belief that these benefits are available only from group-paced instruction may continue to impede the adoption of ICW in military programs of instruction.

B. HOW DOES ICW AFFECT THE ACCUMULATION OF KNOWLEDGE?

Two interesting questions raised by the possibility of significantly more ICW being used for training are: Should we train to the same level of knowledge as with other methods? and Should we train all individuals to the same criteria, or encourage some to gain more knowledge during training?

Individuals in training accumulate knowledge, learn to apply that knowledge individually to perform certain tasks, and then interact collectively to perform tasks that contribute to readiness or warfighting capability. In this paper, we have implicitly assumed that if individual training provides knowledge that results in passing a given set of tests, the performance and readiness results will be the same regardless of the training method. However, even if this assumption is true, a research question with interesting implications for training management and ICW insertion is how this knowledge accumulates under various instructional approaches, and at what cost.

A simple visual representation of: (a) the incremental accumulation of knowledge and (b) the costs of that accumulation is presented in Figure 1. The horizontal axis shows the time (t) spent by one individual in training. The vertical axis shows both the value of the incremental or marginal accumulation of knowledge over time, labeled MP or Marginal Product, and the incremental cost of the time spent under instruction, labeled MC or Marginal Cost.

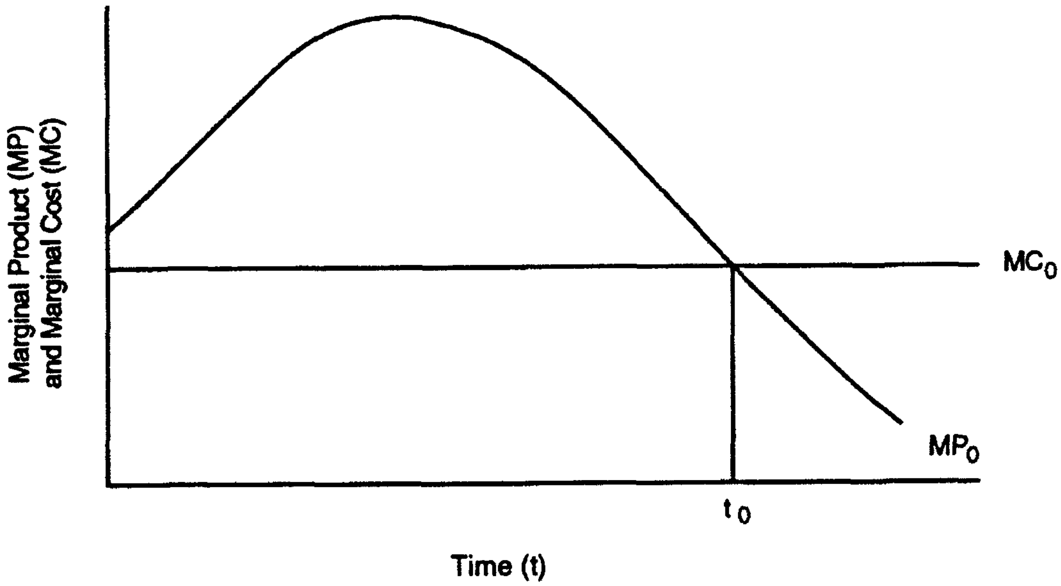


Figure 1. Individual Knowledge Accumulation in Lock-Step Training

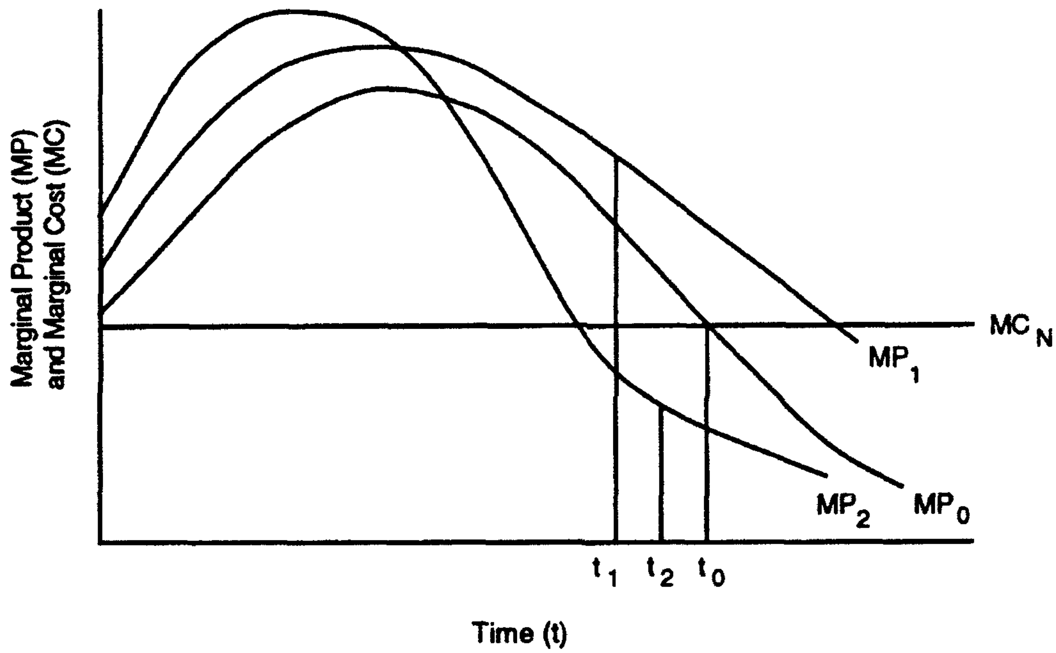
The marginal cost is flat, indicating that any given week is as costly as the last. This is a reasonable assumption since the main course costs that vary with student input are student and instructor pay and allowances. The marginal product curve is based on the assumption that knowledge accumulates slowly at first as individuals learn what seem to be a series of unconnected facts, then rapidly as the knowledge coalesces into a basic understanding of the subject matter, then slowing again as "nice to have" bits of knowledge are added.[21]

From the perspective of cost-effective training, students should be trained for t_0 time, that is, until the MP_0 curve intersects the MC_0 curve as shown. As long as the value of the time spent in class, measured by MP_0, is greater than the cost of that time, measured

[21] The accumulation of the ability to perform activities, such as actually maintaining a weapon system, may have a different MP curve. However, this difference between knowledge and performance occurs regardless of training method, and we have no *a priori* reason to believe it depends on differences between conventional and ICW training methods.

by MC_0, training is cost-effective and should be undertaken. When the value is less than the cost, further training should be terminated.

One of the effects of lock-step training is to force all individuals into a knowledge accumulation pattern similar to that described by MP_0 in Figure 1.[22] The introduction of a self-paced approach such as ICW might result in patterns such as those shown in Figure 2. (Each type of curve has the same interpretation as those in Figure 1, though they do not have to be the same shape.) Each individual accumulates knowledge at a different rate. If testing to criterion is used to pass students on, the areas under these curves would be equal, as shown by the integral.



$$\int_0^{t_i} MP_{t_i} = \text{requirement for all } i$$

Figure 2. Individual Knowledge Accumulation in ICW Training

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22 The actual patterns become much more complicated because students who learn faster or better are forced to wait for their fellow students during each class or section of course material. In lock-step courses, this extra time may be used by those students to better incorporate the knowledge they are gaining into their understanding of the tasks to be trained through further study by tutoring their colleagues, but it may also be wasted. Even if these fast learners are successfully used as tutors, it is not clear that they are cost-effectively used as tutors. This returns to the previous discussion about managing "free" resources.

Providing this conceptual framework allows us insight into several policy issues. For example, it is possible that students will acquire knowledge differently under self-paced or group-paced ICW than under conventional methods.[23] The question could then be asked: Is the current requirement for training the correct requirement under ICW? Quantifying this conceptual framework can aid in addressing this question.[24]

Another policy issue is the question of producing more than minimally qualified trainees. Some argue that self-pacing and testing to criteria mean that those who would eventually become "A" students never do so, because they have not had the extra time imposed on them by being lock-stepped with colleagues who do not learn as fast.

However, this is a management issue. It is certainly possible to allow students who progress more rapidly to cover greater amounts of material, a process that trades the benefit (cost avoidance) of student time savings for the benefit of greater knowledge; quantifying these MP curves for individual students could help guide that decision.[25]

One advantage of ICW instruction is that it will automatically provide the information necessary to construct these MP curves, and lock-step instruction does not. In general, individual MP curves would give us a better understanding of the meaning of the optimal amount of training for each individual.

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[23] For an example of possible differences between group and individualized instruction, see Bloom [29]. He found that students taught in conventional classroom settings scored significantly lower on standard tests relative to students given the same amount of instructional time under individual tutoring. This result led him to say that a key educational challenge is to find instructional methods that give the effect of individual tutoring without the cost. ICW may be one such method.

[24] It may be that the change in the proportion of Navy courses from self-paced to lock-step, mentioned in the discussion of Table 6 (Section II.C.), is a naturally occurring experiment that would allow such an estimate to be developed.

[25] For example, students represented by MP curves such as MP_1 could be allowed to continue training until the value of that additional training equals its cost.

V. SUMMARY OF FINDINGS AND RECOMMENDATIONS

A. SUMMARY OF FINDINGS

At any given time, one of every seven active duty personnel is involved in receiving, giving, or supporting individual training. This activity consumes 6.7% of the annual DoD budget. Due to the increase in both the number of material systems and their complexity, there is every reason to believe that this training will increase in importance with respect to resources consumed and to achieving needed levels of readiness and warfighting capability. Due to possible changes in Total Force policy, such as those that increase the use of Reserve components, instructional delivery methods that can be more decentralized and available on student demand may become more important.

DoD directives and instructions exist that encourage the development and use of innovative technologies for training. One such technology is interactive courseware (ICW). A new DoD instruction tries to develop procedures to make it less costly to: maintain and enhance ICW material, find out about its existence, and disseminate it to interested parties.

The evidence is sparse, but ICW does not appear to be widely used in military training. Many explanations are offered for its lack of use. One possibility is that the costs avoided for individual course components do not translate into savings for course sequences. ICW may be under-used because training policymakers are not aware of the full costs of training or because training managers are not given incentives to manage based on those costs. Also, there may be qualitative benefits that are perceived to result only from group pacing and instructor mediation.

A large body of studies on the cost-effectiveness of ICW has reported favorable results. There are significant time savings by students under instruction, a savings usually estimated at around 30% for individual courses. The development and maintenance costs for these ICW technologies seem to be equal to or less than conventional instructional approaches. Given the forecast price declines in the hardware and software used for ICW, there is every reason to assume its relative cost will fall further.

A rough estimate of the effect of applying these technologies widely in individual, specialized skill training suggests annual cost savings of $130 million-$160 million and student personnel savings of 9-11 thousand.

Increased use of ICW will tend to increase the amount of individualization, including self-pacing, in training. This has the potential to change the way students learn and the amount of knowledge they accumulate. If these changes are significant, they may change the amount and kinds of knowledge and skills we want to provide through training.

B. RECOMMENDATIONS

The data and analyses presented here may not be enough to motivate a complete change in policy with respect to the insertion of ICW into military training. However, several options can be developed based on the material presented:

- Because ICW training appears to be cost-effective, efforts should be made to develop policy direction that would make consideration of such technologies closer to the default approach during major revisions of instructional design and delivery methods.

Our examination of this problem, combined with conversations with training managers, suggest several initiatives that might give incentives for greater use of ICW. One approach would be closer oversight of major overhauls of course material. This is the place where new requirements, design, and delivery approaches will be analyzed in any case, and where investment in courses will be made. It seems to be an appropriate place to inject policy guidance towards investment in ICW technology, because of the cost-effectiveness improvements offered by ICW.

Particular attention should be paid to high throughput courses and course sequences. If it can be shown that, for example, 30% of the training load passes through 5% of the courses, then this suggests concentrating the use of ICW on those courses. Such an example from Navy data is shown in Appendix A.

One way to implement this approach would be to make ICW the rule rather than the exception. Course developers would have to explain why they have chosen *not* to use ICW through the presentation of cost and effectiveness data. There are courses in which use of ICW is not appropriate, and exceptions could easily be justified. On the other hand, this requirement would to some degree ensure that ICW is at least considered in DoD training development.

Another approach would involve creating a small budget item containing funds to be competed for by proposals to apply ICW technology. This would give incentives for individual initiative by training organizations that have evaluated ICW as a promising training technology, but have been unable to generate the budget necessary to undertake the necessary investment.

Whatever policy is suggested should be sensitive to the qualitative issues raised in Section IV.A.2.

- Cost to train estimates should be developed for all individual courses. Estimates such as those being developed under the initiative on unit cost to train might include an individual incremental cost to train, as well as an allocation of course development and BOS costs. [26] Where possible, these data should have some direct, quantifiable relationship to the budget. However, even roughly right estimates would be useful for policymaking purposes.

These estimates should be used to measure the cost of alternative training approaches. In this way training managers will have better information on which to make cost-effective training decisions, for example, in response to the policy direction in the first recommendation.

- Provisions in the instruction on ICW (DoD Instruction 1322.20) should be applied to enhance cost-effective life cycle maintenance, improvement, and dissemination of ICW technology.
- A key question that is not fully answered here is the extent to which ICW and the self-pacing it allows are being utilized in current training. It is hard to evaluate current practice if you do not know what it is. Therefore, rigorous quantification of the use of ICW and self-pacing technologies in training for all services is needed.
- Studies should be done to develop information on the incremental accumulation of knowledge under different instructional delivery systems to gain better insights on whether the current approach of training to specific requirements should be modified for these newer approaches. The desirability of encouraging quick learners to learn more under self-paced instruction should be investigated.
- The effects of policy recommendations with respect to other aspects of training on the cost-effectiveness of ICW should be monitored, and visa versa. In

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[26] For an example of a cost taxonomy that would be more than sufficient for this and many other costing exercises, see Knapp and Orlansky [30]. BOS costs have been found to be influenced by workload (e.g., Levine et al. [31]).

particular, one of the assumptions maintained through this analysis was that the timing of training would be essentially unchanged (see Section III.B). However, the cost-effectiveness of ICW might have an effect on the optimal timing of training, and changes in timing of training could have effects on the cost-effectiveness of instructional design and delivery methods. (For more on the timing of training, see Wilson and Horowitz [14]).

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APPENDIX A

DISTRIBUTION OF TRAINING LOADS AND ESTIMATES OF ICW SAVINGS FOR NAVY INITIAL-SKILL TRAINING

APPENDIX A

DISTRIBUTION OF TRAINING LOADS AND ESTIMATES OF ICW SAVINGS FOR NAVY INITIAL-SKILL TRAINING

INTRODUCTION

The cost savings reported in this paper occur primarily because self-pacing results in less time spent under instruction by students, producing personnel savings by reducing both student and instructor time. These savings have not been realized, in part because service training establishments do not have the incentives to convert to ICW. A key recommendation of this report is to develop these incentives.

One issue that needs to be understood as we try to encourage the insertion of ICW into military training is determining the need for internal or external incentives to undertake this change. This need depends on the number of courses and/or pipelines that would have to be modified to convert 20-25% of the load. If the number of courses that must be converted is large, then a system must be developed that gives individual training managers incentives for ICW conversion without external direction. However, if the number of courses and pipelines to be converted is small, then a sophisticated structure that relies on internally-generated incentives is not necessary. The services can simply direct their training establishments to either convert courses or pipelines in order to get these savings, or to provide data that demonstrate that these conversions are not cost-effective.

SUMMARY

This appendix reports the distribution of student load over the courses that make up Navy Enlisted training. Thirty-one percent of the total Navy enlisted student load in 1989 (13,398 of 43,119) was concentrated in 27 identifiable courses. One of those courses is already converted to self-paced ICW and several of the other courses are non-self-paced ICW. The estimated 20-25% savings through changing the training delivery method of these relatively few courses of instruction appear to be reasonable.

These 27 courses involve 33 different ratings (Navy enlisted occupations), or 44 different instructional pipelines (including six-year initial obligations and nuclear field

specialties). Considering the entire pipeline is important if student time savings due to rapid completion of an earlier, self-paced course are not to be lost while waiting for a later group-paced course to begin. By including the other courses that are part of these pipelines, we raise the identifiable courses to be converted to 72, still only 2.6% of the total courses of instruction in Navy enlisted training that had student throughput in 1989. While a few specific rating pipelines included here may be poor candidates for conversion to self-paced ICW, the basic estimates seem to hold.

Navy student Pay and Allowances was 40% of the $2,108.4 million on which the savings estimate of $130 million to $160 million was based. Therefore, the Navy portion of those savings would be $51 million to $63 million. The personnel savings are in the range of 1,800 to 2,750.

The Navy should be directed to convert as many of these courses as possible, or provide new information that explains why such conversion should not occur. If these results hold, the other services should also be directed to convert to ICW all courses and associated pipelines with more than a specified student load or explain why conversion would not be cost-effective.

The other services were queried for data, but their course data were not available in the form needed for this analysis. While conversations with subject matter experts indicate that these savings are possible in the other services, this cannot yet be documented.

The rest of this appendix discusses the analysis that is summarized above. It reports the Navy data, and the definitions used to distinguish between various kinds of courses. Additionally, it describes how these data were pared down to reveal the relatively small number of courses that contain a large percentage of annual student load. Finally, the proportion of the savings attributable to Navy courses is calculated. The personnel and cost results are summarized, and conclusions and recommendations are presented.

DATA AND DEFINITIONS

The data used in this analysis are Navy data taken from the Navy Integrated Training Resource Analysis System (NITRAS). People in different ratings take different course sequences to order to obtain the training required. This section contains three subsections. The first subsection gives an example of the NITRAS data available for a given course for a particular rating. The second describes two types of course identifiers that are attached to each course and discusses their importance to the analysis. The third

subsection shows examples of how one or more courses fit together to provide the instructional sequence for one rating.

Data for a Given Course

An example of the data for one particular course for one particular rating is presented in Table A-1.

Table A-1. Sample Record Extracted from NITRAS

Type Course	CIN	CDP	Pipeline	Method of Instruction	Days Under Instruction	UI AOB
AP	A-060-0011	611J	FTG-SS	L	29	32.4

Type Course indicators starting with A show initial-skill training courses. There are two different course identifiers, CIN (Course Identification Number) and CDP (Course Data Processing) code, whose definitions will be discussed below. Pipeline shows a particular rating that requires this course, in this case a Submarine Guided Missile Fire Control Technician. Method of Instruction has four possible values depending on whether the course is group- or self-paced, and whether the course material is primarily provided by instructors or some form of ICW. In this case, L is group-paced, instructor-managed.

The number of days actually under instruction is 29, or one day under six weeks. (Another length indicator is Course Length, which includes "internal" weekends. Hence, 10 instructional days (starting on a Monday) means a course length of 12 days, 11 instructional days means a course length of 15.) UI AOB stands for Under Instruction Average-on-Board. It means that, on an average day, there were 32.4 FTG-SS trainees taking CDP 611J. Assuming there are approximately 240 days actually devoted to instruction in one year, a rough estimate of the throughput of this part of the FTG-SS pipeline is 268 [(240/29) × 32.4].[1]

Two Types of Course Identifiers

The two key indicators that identify individual courses are the CIN and CDP code. The best way to give a flavor for the difference between these two indicators is with an example from the civilian educational world. The CIN is the equivalent of identifying

1 We did not ask for the number of graduates in a given year in this data request.

ECON 101 as taught on all campuses of the State University of New York (SUNY). The CDP would be the equivalent of identifying the seats in section 3 of ECON 101 as taught at the Stony Brook campus of SUNY that are set aside for business majors (there are occasional exceptions to the "particular major" part of this analogy). Therefore, there may be multiple CDPs that all use some or all of the course material from one CIN.

Both the CIN and the CDP indicators are important in this analysis. The CINs help identify the number of large student load courses that could be converted to ICW. However, the more different CDPs in each CIN, the more different instructional pipelines are likely to be affected by converting a given CIN to ICW. A mixture of self-paced and group-paced courses in a pipeline might result in individuals rapidly finishing self-paced courses, only to have to wait for group-paced courses to begin, and it is just this sort of pipeline management that is reported as difficult by training managers.

Sample Instructional Pipelines[2]

Many instructional pipelines are extremely simple. For example, in 1989, after recruit training, enlisted personnel who are to become Operations Specialists (OSs) took one course at one location, Operations Specialist A school; enlisted personnel in construction ratings each take their own single A school course, which may be taught at one of two locations. An example of a more complicated pipeline is Engineman (EN). In 1989, enlisted personnel training for this rating took three courses at one location: Propulsion Engineering Indoctrination and Propulsion Engineering Basic (both of which are given to several different ratings), followed by Engineman A School. Additionally, ENs who will serve on submarines then take Submarine Service Enlisted Basic at another location.

An example of a complicated instructional pipeline is Surface Sonar Technician (STG). STGs take four courses, the second of which can be any one of five different courses, each of which may be a different length.

ANALYSES AND RESULTS

Two analyses to identify high AOB CINs are presented below. The first analysis is narrowly defined, looking only at the large CINs, and ignoring the possibility that there would be interactions between these courses and the other courses in given instructional pipelines. The second analysis adds in the additional courses that might have to be

2 For a complete list of initial-skill training pipelines, see [A-1].

converted to gain full ICW benefits for instructional pipelines containing high-volume CINs. This second analysis indicates the effort needed to remove the problem of managing students through an instructional sequence that includes group- and self-paced courses. Managing student throughput in mixed pipelines is one of the primary arguments given as to why it is not worthwhile to convert particular courses in a pipeline to ICW.

Before proceeding with these analyses, the particular subset of data to be further analyzed is identified. Next, each analysis is discussed in turn. For each analysis, the description of the data rearrangements and transformations needed to identify and extract the high-throughput courses is reported. The student load for these large courses or large instructional pipelines is listed and compared with the total student load.

Summary Data

Data that summarize the number and student load in Navy formal school training courses are shown in Section II.C, Tables 4 and 5. The data subject to further analysis will be the courses and load in the initial-skill training type course. These data indicate that there were 314 CDPs that had non-zero UI AOB in FY 1989. The UI AOB load in those courses was 23,048, or 53.5% or the total UI AOB for the year. The reasons for restricting the analysis to these courses are: (1) that these tend to be the courses with the largest student load, and (2) the instructional pipelines—the relationships between courses—are most explicit.

Identification of Likely Conversion Candidates

This subsection describes the data we extracted to yield the 27 courses mentioned in the summary. Basically, the selection was based on two criteria: (1) how certain are we a course is suitable for conversion into self-paced, computer-assisted instruction, and (2) the size of the course as measured by UI AOB. With respect to the first criterion, the more we are likely to know about how a course fits into an overall instructional pipeline, and the more we believe it covers a definite body of tasks and skills knowledge, the more likely we were to select it.

The second criterion is used because conversion to ICW has some fixed costs. If a large course is converted, there are more instructors and equipment saved to offset the fixed costs of conversion. Also, the larger the throughput, the more student time will be saved from the expenditure of that given conversion cost.

The number of CINs and CDPs that were selected and not selected are shown in Table A-2. First, we concentrated only on the initial-skill courses. Many advanced

courses have smaller class sizes, and it is less likely that they must be taken in a particular sequence. However, a further examination of these courses could be undertaken to see if there are a few additional large courses that could be converted, because greater pipeline flexibility and more experienced students may make ICW a more effective training approach.

Table A-2. CIN, CDP, and UI AOB Data Extraction

Category	Initial	No UI AOB	No UI AOB	Sub 1	Ignored	Sub 2	Small	Sub 3
CIN	235	13	0	222	98	124	97	27
CDP	357	27	16	314	122	192	121	71
UI AOB	23,048			23,048	4,212	18,836	4,938	13,398

The first cut occurs because no one took some courses. In the initial-skill group there were 357 CDPs that are part of 235 CINs. In FY 1989, there were 13 CINs (27 CDPs) with no UI AOB, and 16 CDPs with no UI AOB, even though other CDPs in the same CIN had UI AOB. Therefore, there were 222 initial-skill training CINs, making up 314 CDPs, with 23,048 UI AOB in FY 89 as shown under Sub 1 in Table A-2.

The second cut keys on our uncertainty about whether the material is suitable to generate student time savings. It includes courses that were not attached to particular rating pipelines. The latter category includes Apprenticeship training (Airman, Seaman, Fireman) and some courses that include officers. The first part of this cut is a measure of our uncertainty about the courses themselves. It may be that these courses are actually easier to convert to ICW, but it is difficult to know this for certain.

The Apprenticeship training is removed because the material being presented here may have a much stronger component of military practice and team-building than of rating-specific tasks, skills, and knowledge. However, these are large courses and could be reviewed in more detail for potential conversion.

This second cut removed 98 CINs constituting 122 CDPs, and 4,212 UI AOB, and left 124 CINs, 192 CDPs, and 18,836 UI AOB as shown in Sub 2 in Table A-2.

The third cut occurs due to class size. Seventy one percent of the remaining UI AOB is in 22% of the CINs. This removes another 97 CINs, 121 CDPs, and 4,938 UI AOB, as shown in Sub 3 of Table A-2. The remaining 27 CINs are listed in Table A-3.

Table A-3. Remaining Large Courses

Type Course	Course	Days Under Instruction	UI AOB	Indi-cator
Group-Paced, Instructor-Managed				
A1	Electronics Technician A School, Phase II	140	854.0	
A1	Fire Control Technician A School	110	790.7	
A1	Operations Specialist A School	70	750.6	1
A1	Machinist's Mate Nuclear Field A School	60	587.2	
AP	Submarine Service Enlisted Basic	29	464.4	M
A1	Data Systems Technician A School	160	421.2	*1
A1	Electronics Technician Nuclear Field A School	135	412.4	
A1	Electrician's Mate Nuclear Field A School	75	347.2	
A1	Basic Electronics Rate Training	70	249.7	
A1	Music Basic	119	217.5	1
A1	Gas Turbine Systems Technician Mechanical A School	68	212.5	
A1	Gunner's Mate A School Phase I	120	211.1	
	Subtotal		5,518.5	
Self-Paced, Computer-Managed				
AP	Basic Electricity and Electronics	55	770.9	M
Group-Paced, Computer-Assisted				
A1	Avionics Technician A School	111	1,584.0	1
A1	Aviation Electrician's Mate A School	110	715.0	1
A1	Radioman A School	65	583.2	1
A1	Electronics Technician A School, Phase I	85	574.9	
A1	Engineman A School	105	523.0	
A1	Interior Communications Technician A School	110	518.6	*1
AP	Propulsion Engineering Basic	23	486.4	M
A1	Mess Management Specialist A School	35	469.6	*1
A1	Machinist's Mate A School	42	362.5	
A1	Aviation Ordnanceman A School	52	317.7	1
A1	Basic Non-Morse Operations	50	262.0	
A1	Aviation Machinist's Mate A School	42	256.9	1
A1	Aviation Structural Mechanic - Structures A School	46	233.6	1
A1	Air Traffic Controller's A School	80	221.1	1
	Subtotal		7,108.5	
	Total		13,397.9	

Notes: The "indicator" column refers to the kind of pipeline or pipelines with which a course is associated: 1 shows exactly one course in the pipeline, *1 shows one course plus Submarine Service Enlisted Basic for enlisted submariners, and M shows the courses that are given to many different ratings. The remaining courses are either taught to a few ratings, part of multicourse sequences, or both.

These 27 CINs include 31% of the total UI AOB for the Navy in 1989 (13,398 of 43,119). These 27 CINs are only 1% of the total CINs (2,787) that had UI AOB in 1989. One of these courses (Basic Electricity and Electronics) is already self-paced and computer-managed, and 53% of the UI AOB for these 27 CINs is group-paced and computer-

assisted. This means that these group-paced, computer-assisted courses have been partially or completely converted to ICW, but are being taught in a way that probably does not allow all the student time savings to be fully realized.

Even if only half the potential ICW student time savings is still available, converting 12 CINs from group-paced, instructor-managed to self-paced ICW, and 14 CINs from group-paced ICW to self-paced ICW would meet the 20% of student load coverage requirement (5,518.5 + (7,108.5/2) = 9,173, or 21%). Also, conversion costs for the group-paced, computer-assisted courses should be much lower, since much of the work is already done.[3]

One way to understand the effort necessary to make this change is to look at the total number of days of coursework that would have to be converted from lock-step to self-paced. The sum of days under instruction for the 12 lock-step courses above is 1,156, or 4.8 instructional years using 240 days per year. The sources cited in the main text report that these conversion costs will be approximately equal to or less than the savings in instructor pay and allowances and other operations and maintenance cost savings derived from the conversion.

Conversion of the Rest of the Affected Pipelines

Section IV.A.1 reports concerns of training managers that the full benefits of ICW would not be available in course sequences where some of the courses were self-paced and others were group-paced. That is, student time under instruction might be saved in a self-paced course, but wasted as early completers wait for lock-step courses to begin. Such concerns need to be considered here, because these 27 CINs and 71 CDPs cover 33 different ratings and 44 different pipelines. This coverage means that, after these large throughput courses are modified through the inclusion of ICW technology, either care must be taken to integrate them with the non-ICW courses that make up the rest of the pipelines, or the rest of the pipelines need to be converted to ICW.

In order to understand the magnitude of this problem, the CDPs were sorted by rating, and all CDPs were retained in any rating that had one of the large courses. Additionally, if a new CDP/CIN was retained, any rating that used that course was also included. The effects of this addition are shown in Table A-4, which replicates much of

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3 Information in Orlansky [A-2] suggests that more than half of all savings in such conversions comes from self-pacing. If this division of savings applies here, the estimate we have constructed underestimates the potential savings.

Table A-2. As can be seen from the column labeled "Adds," the average UI AOB per CIN for those courses that were added back is quite small.

Table A-4. Revised CIN, CDP, and UI AOB Data Extraction

Category	Initial	No UI AOB	Sub 1	Ignored	Sub 2	Small	Sub 3	Adds	Sub 4
CIN	235	13	222	98	124	97	27	45	72
CDP	357	43	314	122	192	121	71	52	123
UI AOB	23,048		23,048	4,212	18,836	4,938	13,398	2,647	16,045
Av. AOB	98		104	43	152	51	496	59	223

Note: Average UI AOB is average by CIN.

Examples of these additions are Torpedoman's Mate (TM) Submarine Operator (SUB) and TM Surface Operator (SURF). TM(SUB) personnel take Submarine School Enlisted Basic, one of the 27 large CINs, and two additional CINs. TM(SURF) personnel take the same two additional CINs, though they have different CDP identifiers. Therefore, these two ratings contribute two CINs and four CDPs to the "Adds" column.

Additionally, these 72 CINs were cumulated by method of instruction. The results are shown in Table A-5. Once again, assuming only one-half of the savings in the group-paced, computer-assisted courses are still available, 11,009 or 25.5% (11,009 = (8,491.6/2) + 6,762.8) of the UI AOB can be converted. Looking at the total number of lock-step days to be converted yields 2,464, or 10.3 student years of material.

Table A-5. CINs by Method of Instruction

Method of Instruction	UI AOB	Number of CINs
Group-paced, computer-assisted	8,491.6	32
Self-paced, computer-assisted	790.3	2
Group-paced, instructor-managed	6,762.8	38
Total	16,044.7	72

The ratings and pipelines included in the last column of Table A-4 are shown in Table A-6. These pipelines are grouped by general areas. Also, the pipelines that are included as a result of the broader definition are marked with an asterisk. As can be easily seen, many of the pipelines of interest under either approach are in the areas of aviation, electronics/radar/sonar, and propulsion/mechanics. The 12 added pipelines fall into either the Aviation or Other category.

Table A-6. Rating Pipelines Included in Savings Possibilities

Aviation	Electronics/Radar/Sonar	Propulsion/Mechanics	Other
AD	ET	BT	AC
AE	ET-AEF	BT-6YO	BASHEL*
AME*	ET-NF	GM	CTA*
AMH*	ET-SS	GSE	CTO*
AMS		GSE-6YO	CTT
AO	RM	GSM	CTTT
AQ	RM(SS)	GSM-6YO	DS
AQ-6YO		EN	FC
ASE*	STG		IC
ASM*	STS	EM	MS
AT	SWSELEC	EM-NF	OS
AT-6YO		MM	PN*
AV		MM-6YO	PR*
AX		MMN	QM*
AX-6YO			QM(SS)
			SK
			TM(SUB)
			TM(SURF)*
			YN*

Note: See Annex A for a list of rating and pipeline names.

NAVY COSTS AND SAVINGS

The main text uses cost data provided in the MMTR, by the Training Performance and Data Center (TPDC), and in the research literature to develop the all-services savings estimate of $130 million $160 million. This subsection briefly summarizes these data both in the text and in Table A-7, and shows the proportion of these costs that are attributable to the Navy.

The total training funding reported in the MMTR for 1989 is $19.4 billion, $12.9 billion of that amount are direct costs, and $6.0 billion are for specialized-skill training [A-3]. Of the amount for specialized-skill training, $2.1 billion is student pay and allowances. It is assumed that 25% of these pay and allowances can be saved on 25% of the courses, for a total annual savings of $132 million.

The $6.5 billion difference between the total cost and direct cost is made up of indirect costs of training and the cost of training reserves. That amount is made up of Base Operating Support (BOS) costs, Permanent Change of Station (PCS), Temporary Duty (TDY) costs, and Reserve component pay and allowances. Different assumptions are made

about the proportion of these costs that will vary with changes in student pay and allowances. (See Table 10 in the main text.) The proportions together yield an estimate of the indirect cost that varies with student load. The total amount ($2 billion) is added to student pay and allowances to yield $4.1 billion as an estimate of the total cost that varies with student load. Finally, it is assumed that 20% of the courses will be converted, saving 20% of the cost of sending students through the converted courses, yielding savings of $164 million.

Table A-7. All Services and Navy-Only Savings Estimates (1989 Dollars)

Categories	DoD Estimates (Billions)	Navy Estimates (Billions)
Total Budget	$19.4	$5.8
Direct Costs	12.9	4.6
Specialized-Skill Training	6.0	2.0
Active Duty Pay and Allowances	2.1	0.8
25% Time, 25% Cost	.132	.051
Plus Overhead Allocation		
20% Time, 20% Cost	.164	.063

In 1989, Navy student pay and allowances were 38.5% ($810 million) of the $2.1 billion student pay and allowances. Applying that percentage to the $132 million yields $51 million. Assuming the same indirect cost percentage addition, then applying that percentage to the $164 million yields $63 million.[4] The savings of student personnel in the individuals account would range from 1,800 (20% of 9,173) to 2,750 (25% of 11,009).

SUMMARY

For Navy enlisted training, conversion of courses that contain 20-25% of the student load appears feasible. The 20% figure can be attained by converting 12 lock-step CINs, or less than one-half of one percent of all CINs that had UI AOB in 1989, to computer-assisted, self-paced courses, and moving 14 group-paced, computer-assisted CINs, or 0.5% of all UI AOB CINs to self-pacing would generate savings in the 20% range, approximately 1,800 personnel. The 25% figure can be obtained by converting an

4 Once again, by using the extreme estimates (20% and 20% on Pay and Allowances only and 25% and 25% on the costs that include overhead allocation) the range of the estimates could be increased, in this case to $32 million to $98 million.

additional 26 lock-step CINs, (1% of all CINs that had UI AOB in 1989) to computer-assisted, self-paced courses. Moving an additional 18 group-paced, computer-assisted CINs (0.7% of all 1989 CINs with UI AOB) to self-pacing would generate savings in the 25% range, approximately 2,750 personnel. Converting the additional courses to self-pacing means entire instructional pipelines become self-paced, decreasing concerns about problems managing flows of students between courses in a pipeline.

Results of these analyses are encouraging. Thirty one percent of all Navy UI AOB is contained in 27 courses. This means that the expense of developing ICW course material that covers a significant part of the total student throughput should be relatively low compared to the total amount of course material. In addition, approximately half of this subset of AOB is in 14 CINs that are already partially converted to ICW, but being taught in a way that probably does not allow all of the student time savings to be fully realized. Even if one-half the potential ICW student time savings from the partially converted group are already being realized, the other half are still available to be saved. Converting these CINs to self-paced ICW would meet the 20% of student load coverage estimate developed in the main text.

Even including conversion of all courses in affected pipelines, the results are still good. Forty percent of the total Navy UI AOB is contained in 72 CINs that are related to the rating pipelines that contain the 27 largest CINs. If the group-paced courses among the additional 45 CINs were all converted to self-paced, it would increase the overall cost of conversion, though 18 of the additional courses are already computer-assisted, hence they are probably already achieving some of the cost savings from self-pacing. If only half the savings are still available in the group-paced, computer-assisted courses, this still results in 25% of the training load being convertible. However, because the throughput in the additional ratings is small, it might be decided not to convert all those courses.

CONCLUSIONS AND RECOMMENDATIONS

This analysis demonstrates that the student load in Navy enlisted training is concentrated in a relatively small number of courses. It seems desirable to direct the Navy to convert these courses to self-paced ICW unless compelling counter-arguments can be made in specific cases. The other services should be directed to provide the data needed to support similar analyses. If this proves impossible, they should be directed to convert to self-paced ICW courses or instructional pipelines with more than a specified student load unless they can provide convincing arguments to the contrary. This direction should result

in cost savings, less time spent by personnel as both students and instructors in the training establishment, and no degradation of training effectiveness.

REFERENCES

[A-1] Chief of Naval Education and Training. "Navy Enlisted Skill Rating Pipelines," CNET Note 1514, code N-312, Naval Air Station, Pensacola, FL, January 13, 1989.

[A-2] Orlansky, Jesse. "The Cost-Effectiveness of Military Training" in *Proceedings of the Symposium on the Military Value and Cost-Effectiveness of Training*, NATO, DS/A/dr(85)167, (AD B093 505).

[A-3] Military Manpower Training Report FY 1991. Washington DC: Office of the Assistant Secretary of Defense (Force Management and Personnel). (Updated October 1990).

ANNEX A

RATINGS LIST

ABE (Aviation Boatswain's Mate - Equipment)
ABF (Aviation Boatswain's Mate - Fuels)
ABH (Aviation Boatswain's Mate - Handling)
AC (Air Traffic Controller)
AD (Aviation Machinist's Mate)
AE (Aviation Electrician's Mate)
AFFR (Aircraft Fire Fighting and Rescue)
AG (Aerographer's Mate)
AR (Aviation Storekeeper)
AME (Aviation Structural Mechanic - Safety Equipment)
AMH (Aviation Structural Mechanic - Hydraulics)
AMS (Aviation Structural Mechanic - Structures)
AO (Aviation Ordnanceman)
AQ (Avionics Tech - Aviation Control Technician)
AQ (Avionics Tech - Aviation Control Technician - 6YO)
ASE (Aviation Support Equipment Technician - Electrical)
ASM (Aviation Support Equipment Technician - Mechanical)
AT (Avionics Technician)
AT (Avionics Technician - 6YO)
AV Non-Navy (Avionics Technician)
AW (Aviation Anti-Submarine Warfare Operator)
AX (Avionics Technician Aviation Anti-Submarine Warfare)
AX (Avionics Technician Aviation Anti-Submarine Warfare - 6YO)
AZ (Aviation Maintenance Administration)
BASHEL (Basic Helicopter)
BT (Boiler Technician PSI)
BT (Boiler Technician (PSI - 6YO))
BU (Builder)
CE (Construction Electrician)

CM (Construction Mechanic
CTA (Cryptologic Technician)
CTI (Cryptologic Technician)
CTM (Cryptologic Maintenance Technician)
CTO (Cryptologic Technician O)
CTR (Cryptologic Technician R)
CTT (Cryptologic Technician T)
CTT (Cryptologic Technician Others)
DC (Damage Control
DP (Disbursing Clerk)
DP (Data Processing Technician)
DS (Data Systems Technician)
DT (Dental Technician)
EA (Engineering Aid)
EM (Electricians Mate)
EM-NF (Electrician's Mate Nuclear Field)
EN (Engineman)
EO (Equipment Operator)
ET-AEF (Electronics Tecnnician Advanced Electronics
ET (Electronics Technician - Others)
ET-NF (Electronics Technician Nuclear Field)
ET-SS (Electronics Technician Submarine)
EW (Electronic Warfare Technician)
FC (Firecontrolman)
FTG-SS (Fire Control Technician Underwater)
GM (Gunner's Mate)
GSE (Gas Turbine Systems Technician Elec)
GSE (Gas Turbine Systems Technician Elec - 6YO)
GSM (Gas Turbine Systems Technician Mech)
GSM (Gas Turbine Systems Technician Mech - 6YO)
HM (Hospitalman)
HT (Hull Maintenance Technician)
IC (Interior Communications Electrician)
IM (Instrumentman)
IS (Intelligence Specialist)
JO (Information Specialist Journalist)

LI (Lithographer)
ML (Molder)
MM (Machinist's Mate)
MM (Machinist's Mate - 6YO)
MMN (Machinist's Mate Nuclear Field)
MN (Mineman)
MR (Machinery Repairman)
MS (Mess Management Specialist)
MU (Music Basic)
OM (Opticalman)
OS (Operations Specialist)
OTA (Ocean Systems Technician Analyst)
OTM (Ocean Systems Technician Maintainer - 6YO)
PC (Postal Clerk)
PH (Photographer's Mate)
PM (Pattern Maker)
PN (Personnelman)
PR (Aircrew Survival Equipmentman)
QM (Quartermaster)
QM-SS
RM (Radioman)
RM-SS (Radioman Submarines)
RP (Religious Programs Specialist)
SH (Ship's Serviceman)
SK (Storekeeper)
SM (Signalman)
STG (Surface Sonar Technician)
STS (Sonar Technician - Submarine)
SW (Steelworker)
SWS Elec (Strategic Weapon System Electronics)
TM (Torpedoman's Mate Surface Operator)
TM (Torpedoman's Mate Submarine Operator)
UT (Utilitiesman)
WT (Weapons)
YN (Yeoman)

ABBREVIATIONS

ABBREVIATIONS

6YO	six-year obligation
AOB	Average-on-Board
BOS	Base Operating Support
CAI	computer-assisted instruction
CDP	Course Data Processing
CIN	Course Identification Number
CNET	Chief, Naval Education and Training
CPU	central processing unit
DoD	Department of Defense
GUI	graphical user interface
ICW	Interactive Courseware
IDA	Institute for Defense Analyses
MMTR	"Military Manpower Training Report"
NITRAS	Navy Integrated Training Resource Analysis System
O&S	operating and support
OSUT	One Station Unit Training
PCS	Permanent Change of Station
RAM	random access memory
TDY	Temporary Duty
TPDC	Training Performance and Data Center
UI	Under Instruction